ESTUARINE WATER-QUALITY AND SEDIMENT DATA, AND SURFACE-WATER AND GROUND-WATER-QUALITY DATA, NAVAL SUBMARINE BASE KINGS BAY, CAMDEN COUNTY, GEORGIA, JANUARY 1999

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U.S. GEOLOGICAL SURVEY

Open-File Report 00-75

Prepared in cooperation with

U.S. DEPARTMENT OF THE NAVY
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

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Atlanta, Georgia

2000

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ABSTRACT

In January 1999, the U.S. Geological Survey collected estuarine-water, estuarine-sediment, surface-water, and ground-water quality samples in the vicinity of Naval Submarine Base Kings Bay, Camden County, Georgia. Data from these samples are used by the U.S. Navy to monitor the impact of submarine base activities on local water resources. Estuarine water and sediment data were collected from five sites on the Crooked River, Kings Bay, and Cumberland Sound. Surface-water data were collected from seven streams that discharge from Naval Submarine Base Kings Bay. Ground-water data were collected from six ground-water monitoring wells completed in the water-table zone of the surficial aquifer at Naval Submarine Base Kings Bay. Samples were analyzed for nutrients, total and dissolved trace metals, total and dissolved organic carbon, oil and grease, total organic halogens, biological and chemical oxygen demand, and total and fecal coliform.

Trace metals in ground and surface waters did not exceed U.S. Environmental Protection Agency Drinking Water Standards; and trace metals in surface water also did not exceed U.S. Environmental Protection Agency Surface Water Standards. These trace metals included arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, tin, and zinc. Barium was detected in relatively high concentrations in ground water (concentrations ranged from 18 to 264 micrograms per liter). Two estuarine water samples exceeded the Georgia Department of Natural Resources, Environmental Protection Division standards for copper (concentrations of 6.2 and 3.0 micrograms per liter).

INTRODUCTION

Naval Submarine Base (NSB) Kings Bay, a U.S. Department of the Navy (Navy) facility, has been an active Trident Submarine installation since 1982. NSB Kings Bay is located in north-central Camden County, Ga., approximately 4 miles (mi) north of St Marys, Georgia (fig. 1). Informed stewardship of water resources at NSB Kings Bay is based on understanding the hydrology of the base and the effects that the base has on the hydrology. During the period June 1976 through April 1977, an environmental impact statement (EIS) was prepared by the U.S. Army Corps of Engineers (Corps) to provide a baseline for future monitoring at NSB Kings Bay. To recognize environmental changes caused by the construction and maintenance of NSB Kings Bay, a monitoring program was implemented to collect data on estuarine water quality from Kings Bay, the Crooked River, and Cumberland Sound; surface-water quality on and near the base; and ground-water quality of the surficial aquifer on the base.

Data from the monitoring program will be used to evaluate the environmental effects of base activities, including construction and dredging, materials storage, and urbanization. Previous monitoring, by the Navy, included collection of water- and sediment-quality data; description of salt marsh, wetland and upland communities; estimation of benthic, zooplankton, and phytoplankton populations; and analyses of commercial shellfish species for selected contaminants. In this report, the U.S. Geological Survey (USGS), in cooperation with the Navy, report estuarine-water, estuarine-sediment, surface-water and ground-water- quality data for selected locations on and near NSB Kings Bay.

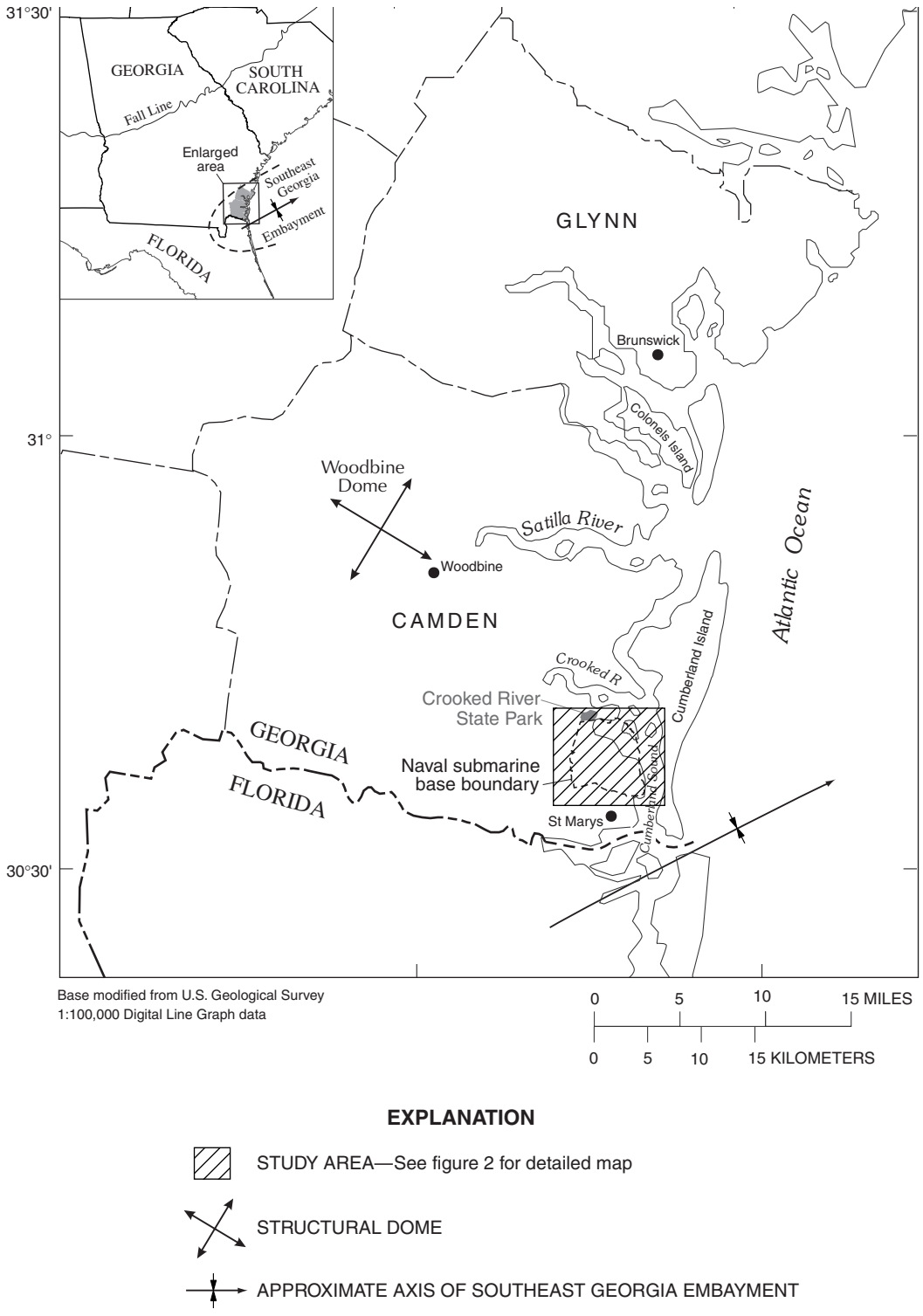


Figure 1. Location of study area, regional structural features, and Naval Submarine Base Kings Bay, Camden County, Georgia.

Purpose and Scope

This report presents estuarine-water, surface-water, and ground-water quality data, including estuarine bed-sediment and bacteria-population data for NSB Kings Bay from samples collected in January 1999. The data collected during this investigation will be used by the Navy to assess the quality of water in the local hydrologic system, including several surface-water bodies located on NSB Kings Bay (the North River, Crooked River, Kings Bay, and Cumberland Sound), and the water-table zone of the surficial aquifer. These data will help the Navy to more efficiently manage and effectively monitor surface-water and ground-water resources that may be impacted by Navy activities on and near the base.

Specifically, the types of data presented are:

- ambient estuarine water-quality data for selected field parameters, nitrogen, phosphorus, bacteria, organics, and trace metals;
- estuarine bed-sediment data for trace metals;
- ambient surface-water-quality data for selected field parameters, nitrogen, phosphorus, bacteria, organics, and trace metals; and
- ambient ground-water-quality data for selected field parameters, organics, and trace metals.

Description of Study Area

The study area encompasses approximately 36 square miles (mi^2) and is roughly centered on the boundary of NSB Kings Bay—including a part of Cumberland Sound (fig. 1). NSB Kings Bay is located in southeastern Camden County, Ga., and is bounded on the north by the Crooked River State Park, on the east by the Crooked River and Cumberland Sound, to the south by the corporate boundary of St Marys, Ga. (fig. 1), and to the west by Georgia State Highway 40 (spur) (fig. 2).

NSB Kings Bay lies in the Barrier Island Sequence District, Sea Island Section of the Coastal Plain Province of Georgia (Clark and Zisa, 1976). Topographic relief across NSB Kings Bay is low, with minimum altitude of sea level to the east and maximum altitude of about 34 feet (ft) to the west. Relief is largely a consequence of relict shorelines formed during global sea level fall (Leve, 1966).

Previous Investigations

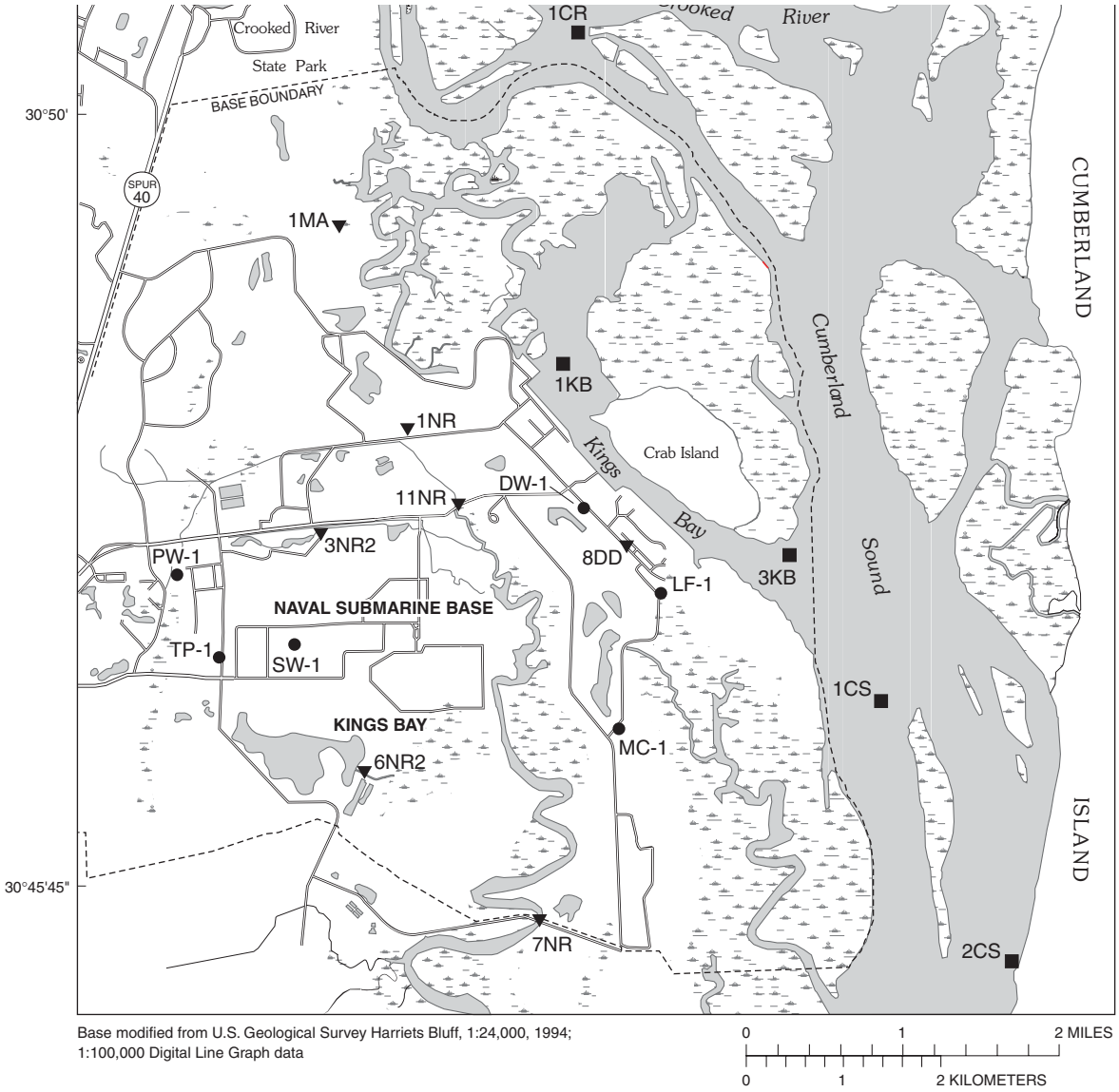
To help understand the effects that NSB Kings Bay may have on the local hydrologic system, the Navy has collected estuarine-water, surface-water, and ground-water-quality data on and near NSB since 1982. These data are included in various unpublished reports including: Alvarez, Lehman and Associates, Inc. (1985, 1986); Jones, Edmunds and Associates, Inc. (1982, 1984a,b); Mote Marine Laboratory, Inc. (1990, 1991); and Water and Air Research, Inc. (1988).

Sources of sediment and sediment transport mechanisms for Kings Bay and vicinity are discussed by McConnell and others (1983) and Radtke (1985). Recent site-specific investigations that have evaluated the hydrology and geology of NSB Kings Bay include remediation-derived reports by the Navy (U.S. Department of the Navy, 1993, 1994a,b). Geologic and hydrogeologic data for NSB Kings Bay are discussed in the initial environmental impact statement for the base (U.S. Army Corps of Engineers, 1977) and in a subsequent report specifically addressing the occurrence of the unconfined ground-water system (U.S. Army Corps of Engineers, 1978). Leeth (1998) described the hydrogeology and water quality of the surficial aquifer (including the water-table zone) near Site 11 (at the northern end of the base).

Brown (1984) evaluated the availability and quality of ground water in eastern Nassau County, Fla., and southeastern Camden County, Ga. In addition, more areally extensive studies include those of Krause and Randolph (1989) who evaluated the Floridan aquifer system using a digital model and compiled an extensive bibliography (including many publications not mentioned here) on the hydrology and geology of southeastern Georgia, and adjacent parts of Florida and South Carolina. Krause and others (1984) presented hydrogeologic data and Clarke and others (1990) investigated the geology and ground-water resources of coastal Georgia.

Well-Numbering System

Observation wells used in this report are numbered according to a system based on the USGS index of topographic maps. Each 7.5-minute topographic quadrangle in Georgia has been given a number and letter designation beginning at the southwestern corner of the State. Numbers increase eastward and letters increase alphabetically northward. Double letters designates quadrangles in the northern part of the area. The letters “I,” “II,” “O,” and “OO” are omitted. Wells inventoried in each quadrangle are numbered consecutively beginning with 1. Thus, the 17th well numbered on the 33E quadrangle is designated 33E017.



EXPLANATION

▼ 7NR SURFACE-WATER SAMPLING SITE AND IDENTIFICATION NUMBER

■ 1KB ESTUARINE WATER SAMPLING SITE AND IDENTIFICATION NUMBER

● MC-1 GROUND-WATER SAMPLING SITE AND IDENTIFICATION NUMBER

Figure 2. Estuarine, surface-water, and ground-water sampling sites on and in the vicinity of Naval Submarine Base Kings Bay, Camden County, Georgia.

Wells used for this study are located on the USGS Harriet's Bluff 7.5 -minute topographic quadrangle that is designated 33E in the well-numbering system outlined above. Information on well locations and construction specifications, and geologic and hydrologic data from this report may be accessed at the USGS Georgia District Office in Atlanta, Ga. A summary of well numbers (grid numbers), well names, location and construction information for wells used in this report is given in table 1.

Table 1. Well number, well name, location, and construction information for wells used in this report

Well name	Well number	Latitude	Longitude	Altitude, in feet		
				Top of screen	Bottom of screen	Land surface
LF-1	33E131	81°30'42"	30°47'24"	11.8	2.3	20.13
DW-1	33E132	81°31'12"	30°47'52"	5.87	-3.63	10.96
MC-1	33E133	81°31'00"	30°46'39"	9.04	-0.46	14.21
PW-1	33E134	81°33'50"	30°47'33"	12.37	7.37	27.37
TP-1	33E135	81°33'34"	30°47'05"	11.45	6.45	26.45
SW-1	33E136	81°33'05"	30°47'09"	6.72	11.53	21.72

METHODS OF INVESTIGATION

Data collection and analysis methods for estuarine water, estuarine sediment, surface water, and ground water are described in this section. Estuarine water-quality samples and estuarine sediment samples were collected at five locations. Surface-water-quality samples were collected at seven locations. Ground-water-quality samples were collected at six locations. All samples and field measurements (pH, dissolved oxygen, and water temperature) were collected in January 1999.

Data Collection

Field measurements and samples for estuarine water, surface water and ground water generally were measured using standard USGS techniques (U.S. Geological Survey 1997–99). In some instances, for consistency with previous work, standard USGS techniques were not used for these field measurements; these exceptions are noted below.

For tidally affected streams and estuaries, measurements were made and samples were collected within one hour before or after low tide. Tidal information was obtained from the National Ocean Service tide tables from the Fernandina Beach reference station. The reference station tide data were corrected to local reference stations, including Kings Bay Navy Base, Harriets Bluff-Crooked River, or Seacamp Dock-Cumberland Island. Corrections were made either by adding or subtracting the local reference station tide minimums to the Fernandina Beach reference station tide and time.

Estuarine and surface-water field measurements for pH, specific conductance, dissolved oxygen, and water temperature were made using a flow-through chamber, with multiple electrodes (Hydrolab II(™)), that was placed in the estuary or stream to make in-place measurements. Before measurement, the electrodes were calibrated, using quality-controlled standards, for pH and specific conductance. Because the Hydrolab II(™) contains a calibrated thermistor, standards were not brought to sample temperature.

For estuarine and surface-water measurements, the flow-through chamber was lowered to the approximate centroid of water flow (the centroid of flow is defined as the point in the increment where discharge in that increment is equal on both sides of the point). For estuaries that have a large cross-sectional area, this is not a standard USGS technique and does not account for variability throughout the water column nor in the cross section. However, this method does replicate methods used for previous sampling efforts, and is standard USGS technique for smaller streams.

After field measurements were completed, estuarine water samples were collected using a high-density polyethylene point sampler (commonly called Van Dorn sampler). For estuarine samples, point samples were collected at mid-channel from the top, middle, and bottom of the water column. These samples were then composited and split using a high-density polyethylene churn splitter. For stream samples, the Van Dorn sampler was used to collect a single point sample at the approximate centroid of water flow.

Fecal bacterial samples for both estuarine and surface water were collected, from the top of the water column, by dipping sterilized sample bottles directly into the estuary or stream. This is not a standard USGS technique for the larger estuaries, but does replicate the methods used by previous workers and is the standard USGS technique for streams. The samples then were chilled in an ice chest and transported for analysis.

Estuarine sediment samples were collected as a part of the study using standard USGS techniques (U.S. Geological Survey, 1997-99); these are briefly outlined here. Estuarine sediment samples were collected using a 216-cubic inch stainless-steel, spring-loaded, Ponor grab sampler. The sampler was hand lowered into the sediment using a nylon line, and a messenger was used to close the

sampler. If the sampler did not close completely or if there was an obvious loss of fine material, the sample was discarded and the sediment resampled.

Ground water field-measurement data and samples were collected according to the standard USGS techniques (U.S. Geological Survey, 1997-99) including calibrating a flow through chamber with multiple sensors (Hydrolab II™), purging the well, and collecting the samples. Calibration procedures for pH, specific conductance, and dissolved oxygen are identical to those described previously. Field measurements for ground water also include pH, specific conductance, dissolved oxygen, and water temperature. Well-purging procedures were as follows

- the static water level was measured, using an electric water-level indicator;
- well volume was calculated based on the static water level, and well depth and diameter;
- a nonaerating, submersible pump was slowly lowered into the well so that particulates were not disturbed; and
- the pump was started and the pump rate adjusted to limit drawdown.

A minimum of three well volumes was purged from the well before samples were collected. In addition, field measurements were recorded during purging. If the field measurements did not stabilize after three well volumes were purged, purging was continued until field measurements stabilized. Both unfiltered (total) and filtered (dissolved) samples were collected. Filtered samples were collected by passing ground water through a 0.45 μm Supor (polyethersulfone) capsule filter.

Quality-control samples were collected to ensure that contamination did not occur during the collection, transport, storage, and analysis of samples. During this study, field-quality control was verified using trip blanks and duplicate samples. Trip blanks consisted of three 40-milliliter (mL) glass vials filled with pesticide-grade water. The trip blanks were transported to the field in insulated coolers, remained unopened in the field, and were sent to the laboratory and analyzed with the samples. The purpose of a trip blank is to assess the impact of shipping conditions on the sample and subsequent data. Duplicate samples also were collected, shipped, and analyzed. The purpose of duplicate samples is to assess any impact on the data of collecting, shipping, and analyzing the samples.

Sample Analysis

Chemical analyses of estuarine-water, surface-water, ground-water samples and estuarine bed-sediment samples were completed by Quanterra Laboratories, Denver, Colo., using standard methods of the U.S. Environmental Protections Agency (EPA) (1983, 1986) (table 2). EPA methods were used to ensure continuity with analyses from previous sampling efforts. In general, data values reported are equal to or less than the detection limits of EPA methods. However, in some instances, estimated or elevated values are reported. These estimated or elevated values usually are a consequence of a laboratory varying from EPA methods. For example, estimated values may be reported when a sample required dilution before analysis.

Table 2. Chemical name and U.S. Environmental Protection Agency method and report numbers

Chemical name	U.S. Environmental Protection Agency	
	Method number	Report designation
Total Kjeldahl nitrogen	0351.2	[1/]MCAWW
Nitrite plus nitrate, as nitrogen[2/]	0353.2	[1/]MCAWW
Orthophosphate phosphorous	0365.3	[1/]MCAWW
Arsenic	6010B	[3/]SW-846
Barium	6010B	[3/]SW-846
Cadmium	6010B	[3/]SW-846
Chromium	6010B	[3/]SW-846
Copper	6010B	[3/]SW-846
Lead	6010B	[3/]SW-846
Mercury	7471A 245.1	[3/]SW-846 [1/]MCAWW
Oil and grease	413.2	[1/]MCAWW
Selenium	6010B	[3/]SW-846
Silver	6010B	[3/]SW-846
Tin	6010B	[3/]SW-846
Total organic carbon	9060 415.1	[3/]SW-846 [1/]MCAWW
Dissolved organic carbon	415.1	[1/]MCAWW
Total organic halogens	9020	[3/]SW-846

[1/]U.S. Environmental Protection Agency (1983).
[2/]Listed as nitrate-nitrite in U.S. Environmental Protection Agency (1983).
[3/]U.S. Environmental Protection Agency (1986).

Estuarine and surface-water samples were analyzed for a variety of constituents including metals, major cations and anions, nutrients, selected organics, and oxygen demand.

Analyses for total metals included cadmium, lead, chromium, copper, zinc, and mercury. Analyses for inorganic constituents include nitrate-nitrite as nitrogen and orthophosphorous phosphorous as phosphate. Analyses for organic constituents include oil and grease, and total Kjeldahl nitrogen. Analyses for oxygen demand include both biochemical oxygen demand (BOD) and chemical oxygen demand (COD).

Both total coliform and fecal coliform bacteria were identified and enumerated according to the membrane filtration (MF) technique of the USGS (U.S. Geological Survey, 1997-1999). This technique involves culturing bacteria after filtering several sample volumes onto gridded membrane filters. After incubation, identification and enumeration is completed by visual inspection and counting; the details of which are given in the standard techniques of the USGS (U.S. Geological Survey, 1997–1999).

Ground-water samples were analyzed for a variety of constituents including metals, major cations and anions, nutrients, and selected organics. Analysis for metals include dissolved and total arsenic, cadmium, lead, selenium, silver, barium, chromium, copper, tin, zinc, and mercury. Analysis for inorganic constituents include only nitrite plus nitrate, as nitrogen. Analysis for organic constituents included oil and grease, total Kjeldahl nitrogen, total organic carbon, and total organic halogens.

ESTUARINE WATER-QUALITY AND SEDIMENT DATA

Estuarine water and sediment in Kings Bay, the Crooked River, and Cumberland Sound were collected and analyzed in January 1999 and the results compared to EPA (1983, 1986) and Georgia Department of Natural Resources, Environmental Protection Division (EPD) standards (1993, 1997). Samples were collected and analyzed for concentrations of total trace metals, oil and grease, orthophosphate as phosphorus, total Kjeldahl nitrogen, nitrite plus nitrate, as nitrogen and total organic carbon (TOC). Measurement of biochemical oxygen demand (BOD), total and fecal coliform, and in-place field parameters were collected using methods previously discussed and are given in table 3. Locations of estuarine sample sites are shown on figure 2.

In general, estuarine water quality did not exceed EPD ambient water-quality criteria (Georgia Environmental Protection Division, 1997). Of seven estuarine water samples analyzed for metals, copper concentrations from two sites exceeded EPD guidelines. Site 2CS had an estimated copper concentration of 6.2 micrograms per liter (μg/L) and site 3KB had an estimated copper concentration of 3.0 μg/L (fig. 2, table 3).These estimated concentrations are below the EPA (1983, 1986) method detection limit of 40.0 μg/L. Total organic carbon concentrations at the five sites ranged from 3.4 mg/L at station 2CS to 4.4 mg/L at station 3KB. Specific conductance of estuarine water ranged from 40,250 microSiemens (μS) at station 1CS to 41,850 μS at station 2CS. Total coliform populations were low, ranging from 2 colonies per 100 mL at site 1CR to 12 colonies per 100 mL at site 3 KB; fecal coliform populations ranged from 3 colonies per 100 mL at site 1CR to 12 colonies per 100 mL at site 3KB. These population counts were too low to be in the ideal count range.

Estuarine sediment samples were collected at the same locations as estuarine water samples. All sampled sites had either measurable or estimated levels of lead, chromium, copper, tin, and zinc, except for copper at site 1CS (table 4), which was not detected. Among trace metals, zinc had the highest concentrations, ranging from an estimated value of 1.4 milligrams a kilogram (mg/kg) to a reported level of 12.6 mg/kg. Chromium concentrations ranged from 1.0 mg/kg to 8.5 mg/kg. Oil and grease were recovered above detection limits at site 1CS (378 mg/kg) and were estimated at the other four sites, with levels ranging from 50.2 mg/kg at 1CR to 173 mg/kg at site 2CS. Levels of total organic carbon in estuarine sediment samples ranged from an estimated detection of 940 mg/kg at site 1CS to 34,000 mg/kg at site 1KB.

Table 3. Physical, chemical, and bacterial characteristics of estuarine-water samples, Naval Submarine Base Kings Bay, Camden County, Georgia

Field properties and constituents, in units	Sites sampled				
	1CR	1CS	2CS	1KB	3KB
Date	01/26/99	01/27/99	01/27/99	01/26/99	01/27/99
Time	1000	1200	1500	1430	0945
Water temperature, ° Celsius	16.7	16.8	16.6	16.7	16.7
Field pH, standard units	7.3	7.9	8.1	7.9	7.0
Specific conductance, µS/cm	40,350	40,250	41,850	41,380	40,680
Dissolved oxygen, mg/L	9.4	8.0	8.2	9.0	7.3
Turbidity (NTU)	3.3	1.8	2.5	1.9	3.8
Total Kjeldahl nitrogen, mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Nitrite plus nitrate, as nitrogen,[1] mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Orthophosphate as P, dissolved, mg/L	0.2	0.1	<0.1	<0.1	0.2
Cadmium, µg/L	<10	<10	<10	<10	<10
Chromium, µg/L	<20	<20	<20	<20	<20
Copper, µg/L	<40	2.6 E, D, G	6.2 E, D,G	<40	3.0 E, D,G
Lead, µg/L	<6	2.0 E, D, G	<6	<6	<6
Mercury, µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Tin, µg/L	<200	<200	<200	<200	<200
Zinc, µg/L	<20	<20	<20	<20	<20
Total organic carbon, mg/L	3.8	3.5	3.4	3.5	4.4
Oil and grease, dissolved, mg/L	<1	<1	<1	<1	<1
Biochemical oxygen demand, mg/L	<2	<2	<2	<2	<2
Total coliform (counts per 100 mL)	2 K	9 K 1	0 K	4 K	12 K
Fecal coliform (counts per 100 mL)	3 K	6 K	6 K	7 K	12 K

[1/]Listed as nitrate-nitrite in U.S. Environmental Protection Agency (1983).

Table 4. Physical and chemical characteristics of estuarine-sediment samples, Naval Submarine Base Kings Bay, Camden County, Georgia

Field properties and constituents, in units	Sites sampled				
	1CR	1CS	2CS	1KB	3KB
Date	01/26/99	01/27/99	01/27/99	01/26/99	01/27/99
Time	1000	1200	1500	1430	0945
Total Kjeldahl nitrogen, mg/kg	405	77.3	596	812	585
Nitrite plus nitrate, as nitrogen[1/], mg/kg	<1	<1	<1	1.8	<1
Orthophosphate as P, dissolved, mg/kg	0.4E	0.5E	2	0.3E	1.6
Cadmium, mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium, mg/kg	5.4	14.5	8.5	3.2	
Copper, mg/kg	1E	<2	1.3E	2.6	0.9E
Lead, mg/kg	2.4	0.6	1.9	3.5	1.4
Mercury, mg/kg	<.03	<.03	<.03	<.03	<.03
Tin, mg/kg	1.8E	1.9E	1.7E	1.7E	1.6E
Zinc, mg/kg	6.1	1.4E	5.6	12.6	3.8
Total organic carbon, mg/kg	5,160	940E	7,250	34,000	3,800
Oil and grease, dissolved, mg/kg	50.2E	378	173E	153E	133E
Percent moisture	31.8	20.9	37.6	74.1	28.4

[1/]Listed as nitrate-nitrite in U.S. Environmental Protection Agency (1983).

SURFACE-WATER-QUALITY DATA

Surface-water-quality samples were collected at seven sites in the study area. A duplicate sample was collected at site 1MA for quality control. Field measurements were made for temperature, pH, specific conductance, dissolved oxygen (DO), and turbidity. Samples were collected to determine several constituents including Kjeldahl nitrogen; nitrite plus nitrate, as nitrogen; orthophosphate; total trace metals; total organic carbon (TOC); oil and grease; 5-day biochemical oxygen demand (BOD5); and chemical oxygen demand (COD) (table 5). Samples also were collected and analyzed for total and fecal coliform. Locations of surface-water-quality sample sites are shown on figure 2.

Concentrations of trace metals and oil and grease were below the detection limits for surface-water samples. Nitrite plus nitrate, as nitrogen concentrations ranged from an estimated value of 0.09 mg/L to 1.1 mg/L. At four sites, nitrate concentrations were below the method detection limit; and therefore below EPD ambient water-quality criteria (Georgia Department of Natural Resources, 1997). Chemical oxygen demand (COD) was detected in five of the eight samples and ranged from an estimated value of 9.4 mg/L at site 11NR to 47.2 mg/L at site 1NR. Biochemical oxygen demand (BOD) was detected at site 8DD, 1MA, and 6NR2 (2.7 mg/L, 2.6 mg/L, and 2.0 mg/L, respectively). Orthophosphate concentrations ranged from below the detection limit to 0.48 mg/L at site 11NR. Total organic carbon in surface water ranged from 8.6 at site 11NR mg/L to 20.5 mg/L at site 8DD.

Physical parameters for surface water varied significantly because of proximity to estuarine water bodies. Specific conductance of surface water at four sites was 148, 156, 173 and 282 μS/cm at 25 ° Celsius; however, three sites—sites 8DD, 1NR, and 7NR—had specific conductances of 3,160 μS/cm, 3,850 μS/cm, and 23,700 μS/cm, respectively, and were probably affected by saltwater. Surface-water pH ranged from 6.8 to 7.6 standard units. Dissolved oxygen concentrations ranged from 2.0 mg/L to 8.7 mg/L. Microbial counts ranged from 80 colonies per 100 mL to 3,330 colonies per 100 mL for total coliform; and 4 colonies per 100 mL to 1,470 colonies per 100 mL for fecal coliform. Two of the microbial samples counted were sparse and below the ideal count ranges for fecal coliform.

Table 5. Physical, chemical, and bacterial characteristics of surface water, Naval Submarine Base Kings Bay, Camden County, Georgia

[Analyses by Quanterra Laboratories, Denver, Colo.; Units: mg/L, milligrams per liter; μS/cm, microSiemens per centimeter at 25 ° C; <, less than; mg/L, micrograms per liter; NTU, nephelometric turbidity units; E, estimated; K, nonideal count; —, data not available]

Field properties and constituents, in units	Stations sampled							
	8DD	6NR2	7NR	1MA	1MA (duplicate)	3NR2	1NR	11NR
Date	01/28/99	01/28/99	01/28/99	01/28/99	01/28/99	01/28/99	01/28/99	01/28/99
Time	09:52	10:55	11:35	13:30	13:40	08:25	09:15	12:40
Water temperature, ° Celsius	17.7	22.3	22.2	21.2	21.2	23.4	20.4	20.4
Field pH, standard units	7.2	7.4	7.3	7.3	7.3	6.8	7.1	7.6
Specific conductance, in μS/cm	3,156	156	23,690	148	148	282	3,850	173
Dissolved oxygen, in mg/L	4.0	6.7	5.5	4.4	4.4	7.3	2.0	8.7
Turbidity (NTU)	3.0	0.68	1.4	3.5	3.3	1.3	1.6	2.2
Total Kjeldahl nitrogen, mg/L	1.4	0.6	<0.5	1.1	1.3	0.87	<0.5	<0.5
Nitrite plus nitrate, as nitrogen[1/], mg/L	<0.1	<0.1	<0.1	0.23	0.21	1.1	0.09 E	<0.1
Orthophosphate as P, dissolved, mg/L	0.08 E	<0.1	0.15	0.05 E	<0.1	0.02 E	0.06 E	0.48
Cadmium, dissolved, μg/L	<5	<5	<5	<5	<5	<5	<5	<5
Chromium, dissolved, μg/L	<10	<10	<10	<10	<10	<10	<10	<10
Copper, dissolved, μg/L	<20	<20	<20	<20	<20	<20	<20	<20
Lead, dissolved, μg/L	<3	<3	<3	<3	<3	<3	<3	<3
Mercury, dissolved, μg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc, dissolved, μg/L	<20	<20	<20	<20	<20	<20	<20	<20
Total organic carbon, mg/L	20.5	10.1	13.7	14	13.9	10.4	16.8	8.6
Oil and grease, dissolved, mg/L	<1	<1	<1	<1	<1	<1	<1	<1
Biochemical oxygen demand, mg/L	2.7	2.0	<2	2.6	2.6	1.9 E	<2	<2
Chemical oxygen demand, mg/L	<20	39	<20	43	235	25	47	9E
Total coliform (counts per 100 mL)	530	80	110	2,330	—	700	2,270	3,330
Fecal coliform (counts per 100 mL)	300	4 K	60	530	—	4 K	600	1,470

[1/]Listed as nitrate-nitrite in U.S. Environmental Protection Agency (1983).

GROUND-WATER-QUALITY DATA

Ground-water-quality data can be used to compare site specific ground-water quality to ambient conditions. Ground-water quality was determined by sampling six shallow monitoring wells completed in the surficial aquifer (fig. 2, table 6). Field measurements of water temperature, pH, specific conductance, and dissolved oxygen were made prior to sample collection. Sampled constituents consisted of total Kjeldahl nitrogen, nitrate plus-nitrite, trace metals, dissolved organic carbon (DOC), total organic carbon (TOC), total organic halogens (TOX), and oil and grease. Samples were analyzed for total and dissolved constituents.

The pH of ground water in the study area ranged from 4.6 to 6.7 standard units (table 6). The pH in four wells (MC-1, PW-1, SW-1, and TP-1) was below the recommended secondary maximum contaminant level (SMCL) range of 6.5 to 8.5 standard units (U.S. Environmental Protection Agency, 1990b) (table 7). SMCL's are aesthetic standards and are not health based. Specific conductance ranged from 260 μS/cm to 9,560 μS/cm. The high conductances are likely due to mixing with estuarine water. Dissolved oxygen was less than 1 mg/L in all of the ground-water samples, indicating that the surficial aquifer is anoxic.

Table 6. Physical and chemical characteristics of ground water, Naval Submarine Base Kings Bay, Camden County, Georgia, January 29, 1999

[T, total; D, dissolved; μS/cm, microSiemens per centimeter at 25 ° Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; <, less than]

Field properties and constituents, in units	Test-well name											
	MC-1		LF-1		DW-1		PW-1		SW-1		TP-1	
	T	D	T	D	T	D	T	D	T	D	T	D
Depth to water (feet below land surface)	4.66	4.66	15.7	15.7	7.97	7.97	4.19	4.19	2.53	2.53	2.9	2.9
Water temperature, ° Celsius	22.3	22.3	22.2	22.2	21.2	21.2	23.4	23.4	20.4	20.4	20.4	20.4
Field pH, standard units	5.5	5.5	6.7	6.7	6.6	6.6	4.6	4.6	6.1	6.1	4.8	4.8
Specific conductance, μS/cm	2,000	2,000	1,500	1,500	9,560	9,560	360	360	307	307	261	261
Dissolved oxygen, mg/L	0.1	0.1	0.2	0.2	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Total Kjeldahl nitrogen, mg/L	6.6Q	7.0Q	8.4Q	8.7Q	2.4	11.0Q	2.1	2.1	0.6	0.6	0.13E	0.10E
Nitrite-plus-nitrate, as nitrogen[1/], mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, μg/L	<10	<10	11.9	<10	<10	<10	<10	<10	<10	<10	<10	<10
Barium, μg/L	56.6	52.5	20	18	152	155	264	259	68.4	65.1	41.8	38.5
Cadmium, μg/L	<5	<5	<5	<5 <	<5	<5	<5	<5	<5	<5	<5	<5
Chromium, μg/L	9E	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Copper, μg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Lead, μg/L	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Mercury, μg/L	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Selenium, μg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Silver, μg/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Tin, μg/L	<100	45E	<100	29E	<100	88E	<100	35E	<100	22E	<100	48E
Zinc, μg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Total organic carbon, mg/L	34.4	—	37.5	—	45.6	—	5.5	—	4.9	—	5.7	—
Dissolved organic carbon, mg/L	—	32.4	—	42.7	—	46.1	—	3.7	—	1.0	—	5.3
Total organic halogens, μg/L	50.3C	37.4C	69.2C	76.0C	70.3C	140.0C	30.6C	29.3E	21.9E	66.6C	33.5	31
Oil and grease, total, mg/L	1.8	1.9	<1	<1	<1	2.4	<1	<1	<1	<1	<1	<1

[1/]Listed as nitrate-nitrite in U.S. Environmental Protection Agency (1983).

Ground-water samples were analyzed for several EPA priority pollutant metals, tin, dissolved organic carbon, total organic carbon, and oil and grease. Trace metal concentrations in ground water were below the EPA's maximum contaminant levels (MCL's) (U.S. Environmental Protection Agency, 1990b) (table 7). Barium was detected in all six wells and ranged from 18 μg/L to 264 μg/L. Using an analytical method with a detection limit of 100 μg/L, dissolved concentrations of tin were between 22 μg/L to 88 μg/L. Arsenic was detected at site LF-1 at a concentration of 11.9 μg/L. Dissolved organic carbon ranged from 3.7 mg/L to 46.1 mg/L. Total organic carbon ranged from 4.9 mg/L to 45.6 mg/L. Oil and grease was detected at sites MC-1 and LF-1.

Table 7. Selected U.S. Environmental Protection Agency, National Drinking Water Standards, primary and secondary maximum contaminant levels

[MCL, maximum contaminant level; SMCL, secondary maximum contaminant levels; mg/L, milligrams per liter; —. not applicable]

Constituents, in units	MCL[1/]	SMCL[2/]
Field pH, standard units	—	6.5 to 8.5
Arsenic, mg/L	0.05	—
Barium, mg/L	2.0	—
Cadmium, mg/L	.005	—
Chromium, mg/L	0.1	—
Copper, mg/L	1.3	—
Lead, mg/L	.015	—
Mercury, mg/L	.002	—
Selenium, mg/L	.05	—
Silver, mg/L	—	0.10
Zinc, mg/L	—	5.0

[1/]U.S. Environmental Protection Agency (1990b).

[2/]U.S. Environmental Protection Agency (1990a).

Carryover occurred during the analysis of the 12 total organic halogens (TOX) samples. Carryover is caused either by high constituent concentrations or improper instrument cleaning procedures. The typical effect of carryover is a small apparent change in constituent concentration values, but very near the actual concentration values.

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